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300 GeV Pion Interactions in Nuclear Emulsion.

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7 pgs.

300 GeV pion interactions in nuclear emulsion.

J. Hébert and I. Otterlund (Spokesmen)

In previous experiments (Project NAL # 116, 233 and)
we have studied the interactions of 200, 300 and 400 GeV protons in nuclear emulsion. From these investigations we have published results about charged particle multiplicities and angular distributions. The publications are listed in enclosure 1.

In the proposed experiment we extend this work to the interactions of 300 GeV negative pions in nuclear emulsion. The aim is to compare the parameters (N_h, n_s, η=ln tg $\theta/2$) with those of the interaction of protons in nuclear emulsion.

The main features of this experiment will be:

1. Measure the average charged particle multiplicity.
2. Compare the yield of secondaries in pion-nucleus collisions to the known ones from pion-proton collisions, in particular with regard to the correlation to the nuclear fragmentation.
3. Measure the angular distribution of the shower particles.
4. Look for any subtle difference between proton-nucleus and pion-nucleus interactions, in addition to the inherent asymmetry, which exists initially at the center of mass system of a pion and a nucleon.
5. Search for charged charmed particles that would decay within less than 1 mm from the primary event.
6. Study the two particle correlation.

Emulsion stacks preparation and processing.

Ilford K5 emulsion will be used. The preparation and milling of the stacks will be done in Strasbourg. After exposure, the horizontally exposed stacks will be processed in Lund and Strasbourg.

Emulsion dimensions and flux requirements.

Flux: ~ 3×10^4 (particles/cm^2).

3 stacks of 40 pellicles ($7.5 \times 10 \times 0.06$ cm^3).

Beam characteristics.

The beam should be as flat as possible over the central region where the measurements will be made. One could expect this region to extend over 2 to 3 cm. Energy of the π-mesons 300 GeV.

Scientific motivation of the experiment.

From the studies of the proton-emulsion interactions at PS-energies and at 200, 300 and 400 GeV we have a general picture of the energy dependence of the observables. In particular the following features have emerged:

1) The correlation between target fragmentation (the number of heavy prongs, N_h) and projectile fragmentation (the number of shower particles, n_s) is strong. The correlation is even stronger between n_s and n_g (the number of grey-prong tracks essentially knock-out protons).

2) The energy dependence of $\langle n_s \rangle_A$ is similar to the energy dependence of the corresponding mean multiplicity $\langle n_s \rangle_{pp}$ in pp-collisions, but may exhibit a somewhat faster growth.

   In particular from 1) and 2) we have that with $R = \frac{n_s}{\langle n_s \rangle_{pp}}$ the quantities $\bar{R} = \bar{R}(N_h)$ and $\bar{N}_h = \bar{N}_h(R)$ depends little upon energy (except for certain contributions of diffractive and coherent type - but such events only influence events with $N_h = 0,1$).

   Also the higher moments of the multiplicity distributions seem to be energy-independent if R and N_h are used as variables.

3) The angular distributions are similar to pp-distributions for angles $\theta < \theta_c$ but the angle θ_c is energy dependent.

The multiperipheral model predicts e.g. that the nucleus should influence the distributions only for values of $\eta_{lab} = -(\ln(tg\theta) - \ln 2)$ such that

$$\eta_{lab} \lessapprox \eta_{lab,crit} \simeq \ln(R_A \cdot m_\pi)$$

with R_A the nuclear radius and m_π the pion mass. This $\eta_{lab,crit}$ is energy independent.

The Gottfried model and other such models predict that $\eta_{lab,crit}$ should grow with energy but not as fast as the data from 200 GeV and 300 GeV seem to indicate.

4) The angle of the leading track (i.e. the track with the smallest angle) seems to be only very weakly correlated to n_s and N_h. This opens the question of the inelasticity of the interaction, in particular what amount of energy that is carried by the leading particle.Different theoretical models do have very definite (and different) predictions in that connection.

   It is possible to disentangle the distribution of the leading proton in different ways from p-A collisions. The angular distribution of that quantity seems to exhibit an A-dependence of the inelasticity. It is known from π-p reactions in bubble chambers that it is a considerable enhancement in the pion production for small angles as compared to pp reactions. This has been explained as a part of a leading mesonic cluster. It is of considerable interest to learn if this mechanism is at work also in π-A collisions.

5) Topological cross section data in the range 30-300 GeV have been found to scale in the variable $z = n_s/\langle n_s \rangle$ with a scaling function similar to that in pp interactions. The scaling function may have a small dependence on the target mass.

6) In the projectile fragmentation region the pseudorapidity distribution is similar to that observed in pp reactions. However, there is a small deficit compared to pp distributions. The rapidity distribution in the target fragmentation region does not change with energy. With increasing target mass the excess is observed in the target fragmentation region and in the pionization region.

The aim of the proposed experiment is to study the general picture of the energy and mass dependence of the observables. In particular it would be fruitful to investigate the difference between the rapidity distributions for pA and πA reactions. From the results of counter experiments (1) there are signs of an eventual cascade mechanism for large angles. In that region it is known from pp and πp reactions in bubble chambers that the production of pion secondaries is very similar. According to the models similar to Gottfried's it is expected that the excess in hadron-nucleus interactions as compared to hadron-proton interactions should be proportional to $(\nu-1)$, i.e. the difference in "the number of collisions":

$$\nu = \frac{A\sigma_{hp}}{\sigma_{hA}}$$

where σ_{hp} and σ_{hA} are cross sections of hadron h on a proton- and on a nucleus with atomic number A respectively. Proton- and pion projectiles have different values of ν for fixed A. Therefore a comparison between proton- and pion-yields for fixed A is sensitive to discrepancies in the assumption that the yield is proportional to $(\nu-1)$.

(1) W. Buza et al. Paper submitted to the XVIII International Conference on High Energy Physics, Tbilisi, 1976.

9. The angular distributions of secondaries in proton-nucleus interactons at 200 and 300 GeV.
B. Andersson, I. Otterlund, Nucl. Phys. B102, 238 (1976).

10. Two-Particle Rapidity Correlations in Proton-Nucleus interactions at 300 GeV.
(collaboration). Nucl. Phys. B103, 213 (1976).

11. Nuclear Interactions of 300 GeV Protons in Emulsion.
J. Hébert et al . Submitted to Phys. Rev. 1976.
Phys. Rev. D. Vol 15 #7, 1867, 1977

12. Nuclear emulsion experiments on particle production at high energies. To appear in Acta Physica Polonia (lectures given by I. Otterlund) 1976.

13. Inclusive production in emulsion with accelerator beams. Proceedings of Topical Meeting on Multiparticle Production at Very High Energy, Trieste 1976 (invited talk I. Otterlund) 1976.

14. Energy dependence of two particle rapidity correlations in proton-nucleus interaction.
G. Baroni et al. Univ. of Roma, Preprint 1976.

15. The A-dependence of the ratio R_A for charged particle production in p-nucleus interactions.
(J. Hébert, H. Areti and C.J.D. Hébert)
to be published - 1977.

16. An estimation of the mass of the "slow bodies" emitted in p-nucleus interactions at 200 and 300 GeV.
(collaboration). University of Ottawa, Preprint 1976.

17. Nuclear interactions produced by 200, 300 and 400 GeV protons in emulsion.
(collaboration). University of Paris, Preprint 1977.

18. Scaling of multiplicity distributions from p-nucleus collisions in emulsion at energies between 6.2 and 300 GeV. Phys. Rev. D, vol. 15, 7, 1874 (1977).

19. An estimate of the mass of the 'slow bodies' emitted in p-nucleus interactions at 200 and 300 GeV. H. Areti et al. Can. J. Phys. Vol. 55, #6, 528 (1977).

Publications from the 200-400 GeV emulsion experiments performed by the Barcelona-Batavia-Belgrade-Bucharest-Lund-Lyon-Montreal-Nancy-Ottawa-Paris-Rome-Strasbourg-Valencia collaboration.

1. 200 GeV proton interactions in nuclear emulsion (collaboration AIP Conference Proceedings Number 12, 131 (1973). J. Hébert et al

2. Study of nuclear interactions of 200 GeV protons in emulsion. (collaboration). Proceedings of Fifth International Conference on High-Energy Physics and Nuclear Structure June 1973, Uppsala, p.427.

3. Nuclear interactions of 200 GeV protons in emulsion. (collaboration). Phys. Lett. 48B, 467 (1974). J. Hébert et al.

4. Multiplicity, Multiplicity Moments and Angular Distributions in Proton-Nucleus Interactions at Very High Energy. Proceedings of the ICTP Topical Meeting on High Energy Collisions Involving Nuclei, Trieste, 1974 (invited talk I. Otterlund).

5. Multiplicity correlations in Multihadron Reaction (B. Andersson, I. Otterlund) Nucl. Phys. B88, 349 (1975).

6. Nuclear Interactions of 200 GeV and 300 GeV Protons in Emulsion. (collaboration). Paper presented at VI Int. Conf. on High-Energy Physics and Nuclear Structure, Santa Fe and Los Alamos, 1975.

7. Some Trends in High-Energy Proton-Nucleus Interactions in Nuclear Emulsions. (collaboration). Proceeding of the 14th Int. Cosmic Ray Conf. Vol. 7, He session, p.2248 (1975), Munich.

8. On the Correlation between the number of heavy prongs and the number of shower particles in proton-nucleus collisions. B. Andersson, I. Otterlund, Nucl. Phys. B99, 425 (1975).